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IDENTIFICATION OF GEOSTRUCTURES OF CONTINENTAL CRUST, PARTICULARLY AS THEY
RELATE TO MINERAL-RESOURCE EVALUATION

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Type II Progress Report for Period 1 January 1973 - 30 June 1973

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<p>Results of the first 6 months study were presented at the NASA Symposium in March and are published in the proceedings. Analysis of lineated lakes in the Umiat, Alaska area and comparison with known geology, gravity and magnetic data in the area suggest concealed structures exist at depth, possibly at or near basement, which may represent targets for petroleum exploration. Results were published in Oil and Gas Journal, May 28, 1973. Compilation of reconnaissance geologic data on 1:250,000-scale enlargements of ERTS images near Corwin reveal structural and stratigraphic anomalies that suggest the Cretaceous sequence is less thick than supposed and is repeated in a series of plates superimposed by flat thrust faults. The structural style differs from that in coeval strata to the northeast, across the northwest-trending linear zone separating differing tectonic styles in older strata noted earlier. The regional extension of a fault known locally in the McCarthy area has been recognized; this fault appears to form the boundary of a significant terrane of mid-Paleozoic metamorphic rocks. ERTS images are being used operationally, at 1:1,000,000 scale in the compilation of regional geologic maps, and at 1:250,000 scale in field mapping in the Brooks Range, in the study of faults in seismically active southern Alaska, in field-checking interpretations previously made from ERTS imagery, and as orthophoto base maps for geologic maps.</p>																
17. Key Words and Document Analysis. (a). Descriptors																
<table border="0"> <tr> <td>Geology</td> <td>Geostructure</td> </tr> <tr> <td>Petroleum exploration</td> <td>Orthophoto</td> </tr> <tr> <td>Structural geology</td> <td>Map</td> </tr> <tr> <td>Faults</td> <td></td> </tr> <tr> <td>Bed</td> <td></td> </tr> <tr> <td>Strata</td> <td></td> </tr> </table>					Geology	Geostructure	Petroleum exploration	Orthophoto	Structural geology	Map	Faults		Bed		Strata	
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Type II Progress Report
ERTS-A

- a. Title: Identification of Geostructures of Continental Crust
Particularly as They Relate to Mineral Resource Evaluation

ERTS-A Proposal No.: SR 180

- b. GSFC ID No. of P.I.: IN 387

- c. Statement and explanation of any problems that are impeding the progress of the investigation:

None, save that mentioned in the Type I Report for 1 January to 28 February 1973; i.e., the effectiveness of the use of ERTS imagery in geologic study of Alaska indicates that the investigation should have been designed as a separate funded program element in order to speed the application of the imagery to the on-going program, rather than as an unfunded adjunct to regularly funded research.

- d. Discussion of the accomplishments during the reporting period and those planned for the next reporting period:

1. Accomplishments during the reporting period:

A proposal for ERTS-B investigations, stressing examination of spectral response of vegetal and lithologic types as indicators of structure and lithologic distribution was submitted. A change in the investigation profile was instituted to permit preparation for and beginning of these studies in the 1973 season.

A paper summarizing results of the investigation through February 1973 and analyzing the resource applications of these results, entitled "Preliminary geologic application of ERTS data in Alaska" by E. H. Lathram, I. L. Tailleux, W. W. Patton, Jr., and W. A. Fischer, was presented by W. A. Fischer at the Symposium on Significant Results Obtained From Earth Resources Technology Satellite-1 held by Goddard Space Flight Center at New Carrollton, Maryland, March 5-9, 1973. The paper was presented in the Technical Session on Mineral Resources, Geological Structure and Landform Surveys and was selected as a key paper to be presented in the Plenary Session. Some of the results were also cited in the summary paper on significant results in Mineral Resource, Geological Structure and Landform Surveys investigations.

Ernest H. Lathram and W. A. Fischer completed a manuscript analyzing in depth the regional distribution of the east-trending lineation in lakes first recognized on image 1004-21395, the relation of this lineation to geologic, geophysical reflection, gravity and magnetic data available, and the petroleum resource implications of the possible buried structures that these data suggest. This paper, "Concealed structures in Arctic Alaska identified on ERTS-1 imagery", was published in Oil and Gas Journal, May 28, 1973.

E. H. Lathram presented an invited paper "EROS Program, ERTS Satellites and Arctic Applications" at the Fifth International Congress of the Fondation Francaise d'Etudes Nordique, in Le Havre, France, May 2-5, 1973. One hundred and seventy-seven invited representatives of private industry, academia, governmental bodies and native organizations from the United States, France, England, Canada, Germany, Italy, Japan, Norway, Sweden, Denmark, Greenland, Belgium, Scotland, The Netherlands, and Finland were present. The theme of the congress was "Arctic Oil and Gas: Problems and Possibilities". The paper addressed not only geological but also other aspects of Arctic exploration and development and discussed known and potential benefits to be derived from the use of ERTS data. Examples from this investigation and others were used in the paper, which will be published in the proceedings of the congress.

George Gryc also presented an invited paper to the congress, "The Analysis of Impact of Oil and Gas Pipeline Systems on the Alaskan Arctic Environment", which dealt with many of the problems whose solution will be facilitated by application of ERTS data.

After the congress, E. H. Lathram conferred with ERTS investigators, A. Fontanel and M. Guy, at the Institute Francaise du Petrole, Paris, France. Techniques and results of their studies of the structure and tectonics of the Alps and this similar study of Alaska were discussed and compared. One of the principal results of their study is the recognition of probable crustal structures not heretofore recognized, a result similar to that reached in the study of Nimbus and ERTS images of Alaska and discussed in previous progress reports of this investigation. Preliminary results of their coastal and marine studies and those of U.S. Geological Survey ERTS investigators studying the Pacific coast of the U.S. were also compared.

Lathram also visited Gian Lupo del Bono, Servizio Geologico d'Italia, Rome, Italy, ERTS-1 and Skylab Co-Investigator with Paul Carlson, U.S. Geological Survey, and discussed progress of the joint investigations which include ERTS and Skylab data study, aircraft underflights by Italian Air Force planes, coastal sedimentation studies, subsea mapping by scuba diving, and subbottom acoustical profiling, all in the vicinity of Elba Island.

In Madrid, Lathram conferred with personnel of ADARO and the Instituto Geologico y Minero, both federal government organizations. The application of ERTS data in mineral resource exploration with examples from Alaska and elsewhere was discussed. By invitation, Lathram gave a lecture on the application of ERTS data to general resource and environmental inventory and management, attended by private industry, academic, and governmental personnel of various disciplines. Examples were drawn from the Alaskan as well as other ERTS and EROS investigations to illustrate the lecture.

E. H. Lathram continued the use of ERTS-1 imagery in depicting the distribution of structures in the compilation of the

Geologic Map of Northern Alaska and in extrapolating mapped geology into unmapped areas. Similar use of ERTS imagery is being made in the final stages of compilation of a new small-scale geologic map of Alaska by H. M. Beikman.

Enlargements at 1:250,000 scale of images 1009-22090, 1046-22143 and 1046-22145 were obtained, covering the western DeLong mountains, Kukpuk River lowland and Lisburne Hills in northern Alaska. I. L. Tailleux is compiling geologic maps of this area, using the ERTS images as an orthophoto base map. No published geologic maps exist as yet in most of this area because of the structural complexity of the strata and the sparsity of field information. The enlarged ERTS image bases provide a more graphic representation of the structural pattern than could conventional maps and assist significantly in extrapolating field data into unmapped areas. In the course of this compilation, Tailleux has found that combining sparse field data with the distribution of structures and strata as shown on the images suggests a significantly more complex geologic framework in the Corwin area than that indicated by earlier reconnaissance study. The new interpretation suggests that the sequence is thinner than supposed and is repeated several times in a series of plates superimposed by flat thrust faults. This structural style differs significantly from that of the Northern Foothills east of the Pitmegea River, where correlative strata are exposed in long, broad, west-northwest-trending synclines, and flat thrust faults, if present, would reach the surface as steep faults along intervening appressed anticlines. It should be noted that the northwest-trending line separating these differing structural styles in younger rocks coincides with the northwest-trending linear zone that separates differing structural regimes in older strata discussed in the paper presented at the symposium.

E. H. Lathram prepared an exhibit showing the application of ERTS imagery to "Petroleum Exploration in Hostile Environments" for the national meeting of the American Association of Petroleum Geologists at Anaheim, California, in early May. The interpretation of the lineation seen on image 1004-21395 (Umiat, area Alaska) previously discussed was stressed. The exhibit also included a comparison of an ERTS image of Oman (1091-06074) and published geologic maps, showing that interpretation of the image could immediately improve the geologic maps; a comparison of an image of the Amazon jungle (1008-13481) and planimetric maps showing errors and changes in drainage since the map was made; and a representation of the effectiveness of ERTS imagery (Image 1005-18171) in depicting the distribution and nature of ice in the Arctic ice-pack.

On image 1043-20163 E. M. MacKevett, Jr., noted the regional extension of a fault mapped locally in the McCarthy area; study of vertical aerial photographs and limited field data indicates that it is the trace of a regionally significant tectonic feature of southern Alaska. The eastern part of this fault may mark the southern boundary of a mid-paleozoic metamorphic terrane that constitutes the westernmost known extent of similar terrane in southeastern Alaska and correlates with the Kaskawulsh Group in Canada.

ERTS-1 images, in 70 mm positive and negative and 9" positive format, have been received of scenes acquired since May 1, 1973, in response to the change in investigation profile requested in January. They are being indexed and filed and have been given a cursory examination for significant features. Many are of scenes not imaged in 1972.

Geologists of the Alaskan Geology Branch, U.S. Geological Survey, participating in the investigation, have acquired 1:250,000-scale enlargements of numerous ERTS images to be used for mapping in the field as well as for checking new geologic interpretations resulting from study of ERTS imagery. G. Plafker and R. L. Detterman are using ERTS images in field study of the present state and history of movement of the major faults of southern Alaska as a part of the U.S. Geological Survey's program of earthquake research. ERTS images are being used by H. N. Reiser as an adjunct to field mapping in the northeastern Brooks Range and by I. L. Tailleux and W. P. Brosge in mapping in the southwestern Brooks Range. Tailleux hopes to make a ground check of the new interpretation of the structure in the Corwin area. W. W. Patton, Jr., is making a groundcheck of the fracture pattern in the Alatna Hills first noted on ERTS image 1072-21180 and discussed in the paper presented at the ERTS Symposium in March.

R. L. Detterman is making a groundcheck in the area of the Umiat image (1004-21395), accompanied by John Koranda, Lawrence Livermore Laboratory, who is a member of the Tundra Biome Group under CRREL auspices. The purpose of this study is to determine the state of disturbances to the tundra caused by the extensive exploration that occurred in the area in the 1945-1952 period. W. A. Fischer pointed out at the ERTS Symposium that if the disturbances had spread "like cancer," as some purport, they should be visible on the ERTS image but are not. It is important to determine the changes these scars have undergone in the intervening 20-year period. The results of these field investigations will not be available until the end of the field season in September.

2. Accomplishments planned for the next reporting period:

E. H. Lathram will begin the systematic study of the ERTS imagery acquired in both 1972 and 1973 of Alaska north of latitude 64° for two purposes: (a) To determine the extent of the known area of lineated lakes observed in the Umiat area, to identify other areas containing such lineations, and to compare gravity and magnetic data and known geology of nearby areas to determine the possible significance of such lineations. (b) to prepare a map of all major lineations and compare these with the general distribution of known mineral deposits and with geologic, gravity, and magnetic data to determine statistical correlations of age and type of deposit with various linear sets. This study has also been proposed by the U.S. as an effort to be conducted as part of the studies of the Joint US/USSR Working Group on the Natural Environment.

Accomplishments achieved by the geologists now utilizing ERTS imagery in the field will be analyzed, and significant results reported.

E. H. Lathram will complete an invited paper entitled "Worth of ERTS and other satellites in effective development of the environment" to be presented at a Symposium on Resource Development and Environmental Conservation sponsored by the Alaska Geological Society in Anchorage, Alaska, Sept. 18-20, 1973. In preparing the paper, the results of other ERTS investigations will be utilized in addition to those of this investigation. The benefits of Nimbus, NOAA and Skylab satellites, and future geostationary ones, will also be discussed.

e. Discussion of significant scientific results and their relationship to practical applications or operational problems including estimates of the cost benefits of any significant results:

Results to date in this investigation indicate:

1. ERTS imagery commonly shows geologic features, primarily those reflecting structural control, which are either too subtle in nature or too regional in scope to be recognized in either field mapping or aerial photo study. In many cases, the significance of these features can only be verified by geophysical techniques or drilling. As a result, the quality of interpretations made of these features depends not only on the degree of professional competence of the interpreter but also on the expertness of his knowledge of the area in question. The benefits to be derived lie in the identification of possible resource exploration targets that would otherwise go unrecognized, such as that suggested by the lineated lakes on image 1004-21395 (Umiat area), and in the formulation of new hypotheses of the relations of regional features and resource deposits that may suggest new approaches in exploration programs, for example, the recognition of previously unrecognized possible crustal fractures, partly from Nimbus and partly from ERTS images and their possible relation to mineralization.

2. The large area covered by each ERTS image provides a pictorially explicit orthophoto view of regional as well as local geologic relations under common conditions of light and vegetation that is not achievable otherwise. The benefits lie in:

- (a) The recognition of gross regional relations not previously recognized that provide data for the formulation or revision of tectonic theories, as in the change in structural style across a linear zone noted on image 1009-22090, in the presence of previously unrecognized fractures within the Kobuk fault zone noted on image 1072-21180, in the anomalous structural and stratigraphic relations noted in compilation of geology on image 1009-22090 (Corwin area), and in the recognition of the regional extension of the fault bounding a mid-Paleozoic terrane in the McCarthy Mountains on image 1043-20163.

- (b) The recognition of the continuity or discontinuity of rock sequences over a large terrane, permitting more effective planning of detailed field study during resource exploration programs, resulting in lower exploration cost and less impact on the surface environment.

- (c) The use of ERTS images at the scale of 1:250,000 for field mapping, extrapolation of known geology into unmapped areas and as base maps for geologic maps, and their use at the scale of 1:1,000,000 to

correct regional geologic compilations and to interpret extensions of geology into unknown areas for such compilations. ERTS images are now being used by the U.S. Geological Survey in Alaska for these purposes, particularly in mapping in the Brooks Range, in mapping of faults in seismically active southern Alaska, and in the compilation of regional maps of northern Alaska and the entire state, speeding the mapping and enhancing the results.

Category 4K

f. A listing of published articles, and/or papers, preprints, inhouse reports, abstracts of talks, that were released during the reporting period:

Lathram, E. H., Tailleur, I. L., Patton, W. W., Jr., and Fischer, W. A., 1973, Preliminary geologic application of ERTS imagery in Alaska (abs.): Symposium on Significant Results Obtained From ERTS-1, Abstracts, NASA/Goddard Space Flight Center, New Carrollton, Maryland, March 5-9, 1973, p. 30.

_____, 1973, Preliminary geologic application of ERTS imagery in Alaska, in Symposium on Significant Results Obtained from Earth Resources Technology Satellite-1: Nat. Aeronaut. Space Adm., Spec. Pub. SP-327, v. I, Section A, p. 257-264.

_____, (in press), Preliminary geologic application of ERTS imagery in Alaska, in Symposium on Significant Results Obtained from Earth Resources Technology Satellite-1: Nat. Aeronaut. Space Adm., Spec. Pub. SP-327, v. II, p. 31-38.

Lathram, E. H., and Gryc, George, 1973, Metallogenic significance of Alaskan geostructures seen from space: Proceedings, Eighth Internat. Symposium on Remote Sensing of Environment, Ann Arbor, Mich., p. 1209-1211.

Fischer, W. A., and Lathram, E. H., 1973, Concealed structures in Arctic Alaska identified on ERTS-1 imagery: Oil and Gas Journal, v. 71, p. 97-102.

Lathram, E. H., (in press), EROS program, ERTS satellites, and Arctic applications: Proceedings, Fifth Internat. Symposium, Fondation Francaise d'Etudes Nordique, Le Havre, France, May, 1973.

Gryc, George, and Lathram, E. H., 1972, Identification of geostructures of continental crust, particularly as they relate to mineral resource evaluation: U.S. Dept. Commerce, Natl. Tech. Inf. Service, NASA-CR-130739, 5 p.

_____, 1973, Identification of geostructures of continental crust, particularly as they relate to mineral resource evaluation: U.S. Dept. Commerce, Natl. Tech. Inf. Service, NASA-CR-131316, 5 p.

Gryc, George, and Lathram, E. H., (in press), Identification of geostructures of continental crust, particularly as they relate to mineral resource evaluation: Type I Progress Report to NASA, Period 1 March 1972 to 31 May 1972.

Lathram, E. H., (in press), Worth of ERTS and other satellites in the effective development of the environment (abs.): Symposium on Resource Development and Environmental Conservation, Alaska Geological Society, Anchorage, Alaska, September 18-20, 1973.

g. Recommendation concerning practical changes in operations, additional investigative effort, correlation of effort and/or results as related to a maximum utilization of the ERTS system:

The maximum utilization of the ERTS system in overall resource and environmental applications requires a continuity of data. The delay of ERTS-B launch raises the spectre of a gap in data should ERTS-1 fail. The failure of the RBV tape recorder, and then of the RBV system showed the fallibility of the systems. The current failure of the MSS tape recorder is an additional blow. While the immediate effect will be felt in countries lacking a receiving facility (representing a serious and nationally embarrassing gap in data provision for foreign countries and investigations), the long-range effect on U.S. applications is to heighten the possibility of MSS failure and a gap in ERTS data before ERTS-B is launched.

Discussions with private individuals, county and state land-use and resource planners and managers, and investigators both in the U.S. and in Europe have revealed not only an intense interest in and need for ERTS-1 data, but also a strong requirement for continuance, i.e., launch and maintenance of ERTS-B or an operational satellite before, or at least as soon as the demise of ERTS-1. Particularly in Europe, the public awareness of the ERTS satellite was striking.

All effort should be focused toward an early follow-on by ERTS-B.

A recommendation of change in Principal Investigator on this investigation from George Gryc to Ernest H. Lathram has been made.

h. A listing of data of any changes in Standing Order Forms:

Change of data requested from 9" paper prints to 70 mm and 9" transparencies, and the addition of a data requirement for the period May 1 to August 1, 1973, was accomplished in conference with the Technical Monitor. The change to transparencies will permit initiation of color enhancement study of structure and lithologic distribution, and the addition of the spring-summer 1973 period will ensure complete coverage of Alaska (now incomplete) as well as comparison of spectral changes in geologically affected vegetation biomes from one growing season to another and throughout a growing season.

i. ERTS Image Descriptor forms:

None.

j. Listing of date of any changed Date Request forms submitted to
Goddard Space Flight Center/NDPF during the reporting period:

None except for change noted in paragraph h. above.